

A.24 Vernal Pool Tadpole Shrimp (*Lepidurus packardii*)

A.24.1 Legal Status

The vernal pool tadpole shrimp (*Lepidurus packardii*) was listed as endangered throughout its range under the Federal Endangered Species Act on September 19, 1994 (59 FR 48136). In September, 2007, USFWS published a 5-year review recommending that the species remain listed as endangered. Revised critical habitat was designated on February 10, 2006 (71 FR 7118). This species is covered by the December 15, 2005, Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. None of the critical habitat units are within the BDCP Planning Area; however, one unit (Unit 11 A-D) is just west of the BDCP Planning Area in Solano County.

The vernal pool tadpole shrimp has no state regulatory status.

A.24.2 Species Distribution and Status

Range and Status

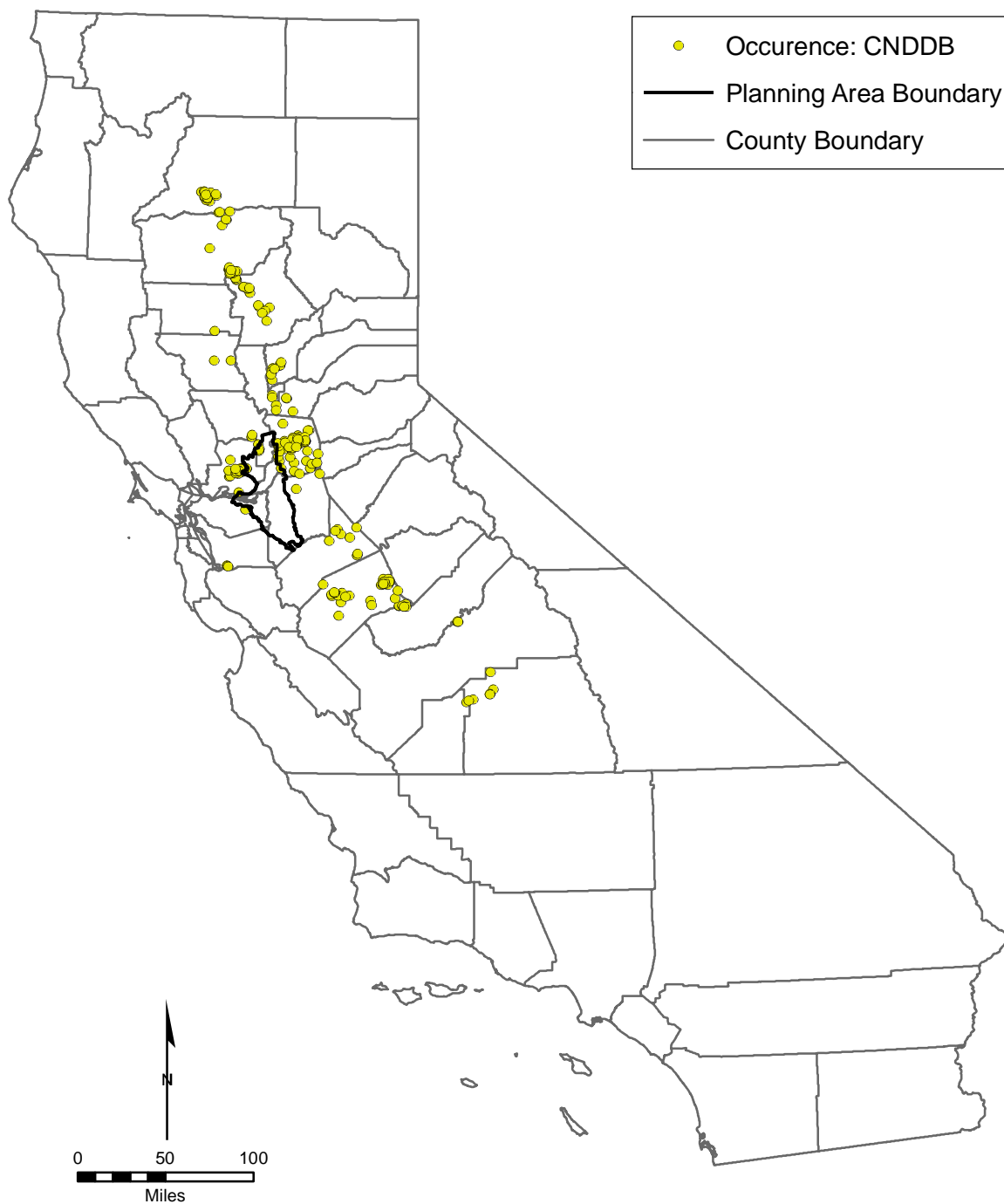
The vernal pool tadpole shrimp is distributed across the Central Valley of California and in the San Francisco Bay area (Figure A.24.1). Populations are found at 18 vernal pool complexes in the Sacramento Valley from east of Redding in Shasta County south through the Central Valley to the San Luis National Wildlife Refuge in Merced County. It also occurs in a single vernal pool complex located on the San Francisco Bay National Wildlife Refuge in the City of Fremont, Alameda County. The easternmost known location is around 3,500 feet in elevation in the central Sierra Nevada foothills (Merced County), with the westernmost known locations in the San Francisco Bay Area (Alameda County). The Bay Area location is the only known population of the vernal pool tadpole shrimp outside of the Central Valley (USFWS 2005, 2007). The largest concentration of vernal pool tadpole shrimp occurrences is found in the Southeastern Sacramento Vernal Pool Region, where the species occurs on a number of public and private lands in Sacramento County (USFWS 2005, 2007).

Distribution and Status in the Planning Area

Vernal pool tadpole shrimp has been reported from several locations within the BDCP Planning Area (Figure A.24.2) (USFWS 2005, 2007, CNDDDB 2008). In general, within the BDCP Planning Area vernal pools that may support the species occur on alkaline soils from the DFG Tule Ranch Reserve southwest to the Montezuma Wetlands Mitigation Projects and from the Byron Airport to Discovery Bay. Other potential vernal pool habitat occurs along the eastern boundary of the BDCP Planning Area near Stone Lakes.

A.24.3 Habitat Requirements and Special Conditions

The vernal pool tadpole shrimp is entirely dependent on the aquatic environment provided by vernal pool wetland ecosystems. Habitats supporting the vernal pool tadpole shrimp are typically in Central Valley California floristic provinces below 300 m (984 feet) elevation (USFWS 2005). Typical habitat for vernal pool tadpole shrimp in California includes vernal pools, seasonally ponded areas within vernal swales, rock outcrop ephemeral pools, playas, and



Source: California Department of Fish and Game, CNDDB, 2008.

Figure A.24.1. Vernal Pool Tadpole Shrimp Statewide Recorded Occurrences

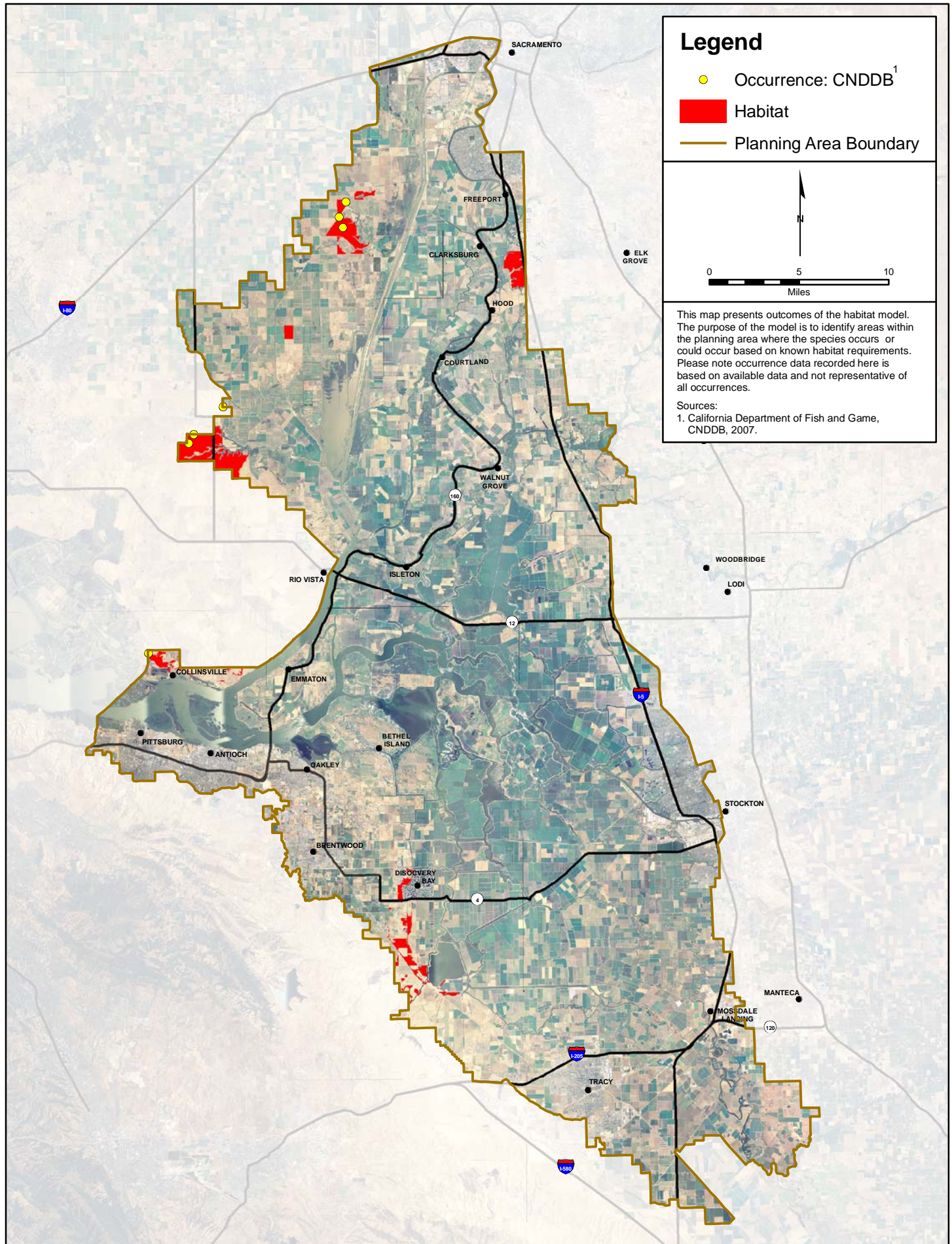


Figure. A.24.2. Vernal Pool Tadpole Shrimp Habitat Model and Recorded Occurrences

1 alkali flats (Eriksen and Belk 1999, Rogers 2001). Vernal pool tadpole shrimp have been found
2 in pools ranging from 2 m² to greater than 32 ha (0.1 to 80 acres) (Helm 1998, Eriksen and Belk
3 1999, USFWS 2005).

4 The vernal pool tadpole shrimp is a component of a larger invertebrate community structure
5 (Rogers 1998). This invertebrate community includes mostly planktonic Crustacea dependent on
6 temporary wetlands, including copepods, cladocerans, and ostracodes as well as flatworms and a
7 suite of insect species, including vernal pool haliplid beetle (*Apterliplus parvulus*), scimitar
8 backswimmers (*Buenoa scimitra*), Ricksecker's hydrochara (*Hydrochara rickseckeri*), and many
9 others (Rogers 1998). These habitats are usually low in opportunistic species like mosquitoes
10 and chironomid midges in the genus *Chironomus* (Rogers 1998).

11 Vernal pool tadpole shrimp commonly co-occur with the fairy shrimp (*Lindleriella occidentalis*,
12 *B. conservatio*, *B. lindahli*, *B. coloradensis*) and the vernal pool fairy shrimp (*B. lynchi*). The
13 midvalley shrimp (*B. mesovallensis*) and *B. longiantenna* both occur within the range of the
14 vernal pool tadpole shrimp but are typically found in different habitats (USFWS 2005, 2007).

15 **A.24.4 Life History**

16 **Feeding.** Vernal pool tadpole shrimp are omnivorous, with a strong preference for animal
17 matter, and will capture and consume live invertebrates including fairy shrimp and other vernal
18 pool tadpole shrimp, amphibian larvae, or carrion, and also filter detritus for micrometazoa
19 (USFWS 2005, 2007).

20 **Ecology.** Vernal pool tadpole shrimp are adapted to the environmental conditions of their
21 ephemeral habitats. One adaptation is the ability of the vernal pool tadpole shrimp eggs, or
22 cysts, to remain dormant in the soil when their vernal pool habitats are dry. The cysts survive the
23 hot, dry summers and cold, wet winters that follow until the vernal pools and swales fill with
24 rainwater and conditions are right for hatching. When the pools refill in the same or subsequent
25 seasons some, but not all, of the eggs may hatch. The egg bank in the soil may comprise eggs
26 from several years of breeding (USFWS 2005, 2007).

27 The life span of vernal pool fairy shrimp allows it to hatch, mature to adulthood, and reproduce
28 during the short time period when vernal pools contain water. When reared in plastic pools with
29 their bottoms lined with soil excavated from vernal pools and without supplemental food this
30 species completed its lifecycle in an average time of 54 days (Helm 1998). Other researchers
31 have recorded maturation periods varying from 21 to 28 days (Ahl 1991, King 1996). Vernal
32 pool tadpole shrimp have relatively high reproductive rates and also may be hermaphroditic. Sex
33 ratios can also vary, perhaps in response to changes in water temperature.

34 Genetic variation among vernal pool tadpole shrimp was studied in populations at 20 different
35 sites in the Central Valley (King 1996). The results found that 96 percent of the genetic variation
36 measured was due to differences between sites. This result corresponds with the findings of
37 other researchers that vernal pool crustaceans have low rates of gene flow between separated
38 sites. The low rate of exchange between vernal pool tadpole shrimp populations is probably a
39 result of the spatial isolation of their habitats and their reliance on passive dispersal mechanisms.
40 However, the studies also found that gene flow between pools within the same vernal pool
41 complex is much higher. This indicates that vernal pool tadpole shrimp populations, like most
42 vernal pool crustacean populations, are defined by vernal pool complexes and not by individual
43 vernal pools (USFWS 2005).

Vernal pool tadpole shrimp are a component of the zooplanktonic community within episodic, ephemeral aquatic habitats although the larger they grow, the more time they spend feeding at, or near, the bottom of the pools (USFWS 2005).

A.24.5 Threats and Stressors

Threats to vernal pool habitat and species in general, including vernal pool tadpole shrimp, were identified in the Recovery Plan (USFWS 2005). In addition, the Recovery Plan identified several threats specific to the vernal pool tadpole shrimp.

Habitat loss and fragmentation. Habitat loss and fragmentation were identified as the largest threats to the survival and recovery of vernal pool species. Habitat loss generally is a result of urbanization, agricultural conversion, and mining and can also occur as a result of habitat alteration and degradation due to changes to natural hydrology, invasive species, incompatible grazing regimes (including insufficient grazing for prolonged periods) (Marty 2004), infrastructure projects (such as roads and utility projects), recreational activities (such as off-highway vehicles and hiking), erosion, climatic and environmental change, and contamination. Habitat fragmentation is a threat to vernal pool invertebrates by preventing waterfowl or shorebirds from feeding at the pools, thereby preventing genetic flow between occupied habitats, as bird species act as dispersers of vernal pool tadpole shrimp cysts. Habitat fragmentation is also related to habitat loss when individual vernal pools become disconnected and isolated as a result of activities such as road development and other infrastructure projects. Widespread urbanization and the construction of infrastructure are major contributors to the loss of vernal pool habitats and their associated species. In addition, gravel and clay mining operations that are needed to support urban developments, including roads and other infrastructure, have resulted in the destruction of vernal pools (USFWS 2005, 2007).

Agricultural Conversion and Incompatible Livestock Grazing Practices. Conversion of land use, such as from grasslands or pastures, to more intensive agricultural uses (e.g., croplands) or from one crop type to another, has contributed and continues to contribute to the decline of vernal pools in general (USFWS 2005, 2007).

Competition from Invasive Species. Vernal pool plant species have declined due to the introduction of invasive, non-native plant and animal species. Increasing dominance by competitors may also contribute to changes in hydrology and livestock grazing practices. Introduction of the bullfrog (*Rana catesbeiana*), a voracious predator on many species of native and non-native animals, to areas inhabited by the vernal pool tadpole shrimp appears to be a threat to this species where perennial water bodies suitable for bullfrog breeding are near seasonal water bodies suitable for shrimp (USFWS 2005). Vernal pool tadpole shrimp are known to have been parasitized by flukes (Trematoda) of an undetermined species at the Vina Plains Preserve, Tehama County, which may be a limiting factor affecting reproduction of this species in this area. In addition, vernal pool tadpole shrimp are threatened by the encroachment of non-native annual grasses on the San Francisco Bay National Wildlife Refuge (USFWS 2005).

Altered Hydrology. Changes in hydrology that result in a change in the timing, frequency, and duration of inundation in vernal pools can create conditions that render existing vernal pools unsuitable for vernal pool species (USFWS 2005). The vernal pool complexes in areas proposed for road improvements could be affected by alteration of hydrology which could diminish habitat for vernal pool tadpole shrimp (CNDDB 2008).

Contamination. Slight changes in water chemistry directly affect sensitive vernal pool species, especially vernal pool crustaceans. Water contamination can occur from herbicides, fertilizers, and other chemicals commonly used in urban and agricultural settings. Pesticide applications for combating West Nile virus, a disease transmitted by infected mosquitoes, may also affect fairy shrimp species. Fertilizers may also contribute to the growth of invasive plants (USFWS 2005). Vernal pool tadpole shrimp populations on the Stone Corral Ecological Reserve in Tulare County may be threatened by pesticide drift from adjacent farmlands.

Other threats. Several other threats to vernal pools and their associate species in general were identified in the Recovery Plan. Although not specifically identified as a threat to vernal pool tadpole shrimp, these threats contribute to the decline of vernal pool habitats, which will affect all species that are dependant on functional vernal pool habitats for survival. Human use and recreational activities, such as off-road vehicle use, hiking, and bicycling, threaten vernal pool ecosystems. When access is through vernal pool complexes, hydrological functions may be impaired by displaced soil causing erosion or interrupting swale connectivity. Also, off-road enthusiasts, such as bicyclists, may create dirt jump ramps, which also could result in the burial of seeds and cysts of plants and animals or soil compaction. Recreational users also may introduce, or facilitate spread of, invasive plants or dispose waste and debris into vernal pool habitat and alter the ecology (USFWS 2005).

Habitat alteration may also occur due to large-scale climate and environmental changes, such as global warming, that lead to changes in the precipitation pattern and atmospheric conditions. Most of the populations of vernal pool tadpole shrimp are isolated from other populations and are distributed in discontinuous vernal pool systems; small, isolated populations are vulnerable, which could result in extirpation from a particular area (USFWS 2005, 2007).

A.24.6 Relevant Conservation Efforts

The vernal pool tadpole shrimp is protected as a threatened species under the Endangered Species Act, and critical habitat has been designated as noted above. The locations of the species within the BDCP Planning Area, however, are not included in any of the designated critical habitat areas. In the Solano-Colusa Vernal Pool Region, vernal pool tadpole shrimp are protected in Jepson Prairie Ecosystem, including the Burke Ranch and Jepson Prairie Preserve owned by the Solano County Open Space and Farmland Conservancy (USFWS 2005, CNDDDB 2008).

Although conservation efforts have been taken for vernal pool ecosystems in general, very few actions have been taken specifically to benefit the vernal pool tadpole shrimp. An example of one of these actions is a grazing program at the Stone Corral Ecological Reserve for the benefit of vernal pool crustaceans that is being monitored by California Department of Fish and Game staff (USFWS 2005).

The longhorn fairy shrimp is covered under the Natomas Basin, San Joaquin County, East Contra Costa County Habitat Conservation Plans. In addition, the species is proposed for coverage in the Solano County, South Sacramento County, and Yolo County Habitat Conservation Plans currently under development.

A.24.7 Species Habitat Suitability Model

Habitat. Vernal pool fairy shrimp habitat was identified in areas with alkaline soils as Natural Seasonal Wetlands and Grasslands on Antioch (AoA), Capay (Ca, Cc), Clear Lake (Ck), Diablo

(DaC), Hillgate (HcA), Marcuse (Mb, Mc, Sb), Marvin (Mf), Pescadero (Pc, Pk), Rincon (Rg), Scribner (245), and Solano (Sh, Sk) soils (Figure A.24.2). For areas along the eastern border of the BDCP Planning Area that do not occur on alkaline soils habitat was determined by the presence of vernal pool and swale microtopography. Vegetation types designated as species habitat in this model correspond to the mapped vegetation associations in the BDCP GIS vegetation data layer (Hickson and Keeler-Wolf 2007). Aerial imagery (USDA 2005) and LiDAR elevation data (DWR 2007) were used to determine how intensively parcels included in the model had been farmed as the vegetation data included significant areas of fallow agricultural land that had been misclassified by DFG as various classes of natural vegetation. Parcels without natural vernal pool and swale vegetation signatures and microtopography were deleted from the area of predicted habitat. Additionally, parcels with known occurrences were digitized and included as habitat.

Assumptions. Historical and current records of this species in the BDCP Planning Area indicate that its current distribution is limited areas with vernal pool and swale microtopography along the upland edges of the BDCP Planning Area (Witham 2003, 2006, CNDDDB 2008) and areas with swales and vernal pools along the eastern boundary of the BDCP Planning Area (Figure A.24.2) (CNDDDB 2008). Artificial impoundments such as stock ponds or roadside ditches, that are known to provide habitat for this species, were not included in the model.

A.24.8 Recovery Goals

A general statement for recovery of vernal pool tadpole shrimp is presented in the USFWS (2005) Recovery Plan: to ensure protection of the full geographic, genetic, and ecological extent of this species and to improve the circumstances that caused it to be listed in the first place. Interim goals are to (1) stabilize and protect populations, (2) conduct research to refine reclassification and recovery criteria, and (3) downlist endangered species to threatened. Vernal pool habitats used by the species as well as historical and potential habitats need to be protected, and habitat management plans for these habitats need to be developed and implemented. Recovery criteria have been established in the Recovery Plan (USFWS 2005).

The criteria to downlist the species are to protect 80 percent of this species existing occurrences and 85 to 95 percent of this species suitable habitat within 13 Core Areas, including: Chico, Oroville and Vina Plains, Grasslands Ecological Area, Davis Communications Anex, Jepson Prairie, Collinsville, Sacramento NWR, Consumnes/Rancho Seco, Mather, Madera, Merced, and Table Mountain. Eighty-five percent of suitable habitat is to be protected within 11 Core Areas, including: SE San Francisco Bay, Dales, Doe Mill, Red Bluff, Redding, Cross Creek, Dolan, Beale, Western Placer County, Cottonwood Creek, and Turlock. The criteria to delist the species are: protect 100 percent of newly discovered/reintroduced populations and reintroduce the species into vernal pool regions and soil types from which surveys indicate that it has been extirpated (USFWS 2005).

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